

# DISORDERS OF BODY SCHEME AFTER STROKE

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## SUMMARY

**Background and purpose.** *The aim of this study was to determine if brain lesions located in the parieto-temporo-occipital area (PTO) are associated with such disorders of body scheme as autotopagnosia, finger agnosia and right-left disorientation, if these disorders result from damage to the left or right brain hemisphere, and if other cognitive disorders may be influencing test results in studies of body scheme disorders.*

**Material and methods.** *Two groups were examined: 16 patients after stroke in the right or left PTO and a control group consisting of 11 persons with no brain lesions. In three clinical trials three aspects of body scheme were tested: localizing body parts, finger gnosis, and right-left orientation. Other neuropsychological methods were used to test visual gnosis, praxia, visuospatial abilities, language, attention and memory. Results were compared from the experimental and control groups, and from two subgroups of patients with left- or right-sided brain lesions.*

**Results.** *There was a significant difference between the experimental and control groups in terms of finger gnosis. Poor performance was observed particularly among patients with right hemisphere lesions. In the experimental group there were also other cognitive disorders, such as visual agnosia, constructional apraxia and visuospatial disorders. No significant correlation was found in the examined population between the level of these disturbances and body scheme disorders.*

**Conclusions.** *The finger agnosia observed in this population of patients occurred more frequently after lesions to the right brain hemisphere. Autotopagnosia and finger agnosia seem to be independent of coexisting cognitive disorders.*

## INTRODUCTION

Body scheme disorders in patients with brain damage have been reported since the end of 19th century. However, many questions concerning this

issue still remain unanswered. The diffuse terminology and numerous competing definitions reflect the conceptual complexity of the body scheme and its disorders. There are two main aspects of body scheme:

- a general consciousness of the appearance of one's own body and its spatial features;
- particular functions, such as localizing body parts, finger gnosis, and right-left orientation (Denburg & Tranel 2003, Haggard & Wolpert 2005).

Disorders of the latter, special aspects of body scheme may affect the patient's activity after stroke, and thus have an unfavourable impact on her rehabilitation. Specific research methods can be used to diagnose these disorders.

The location of brain areas responsible for body scheme remains unclear. This is probably the result of the fact that body scheme disorders frequently co-occur with impairment of other cognitive functions. The role of the parietal lobes, particularly the temporo-parieto-occipital junction (TPO), has been emphasized in many publications (Felician et al. 2003). The left cerebral hemisphere (LH) seems to be associated with body scheme, but some researchers (Denburg & Tranel 2003) suggest that body consciousness is mediated by the right hemisphere (RH). There are two trends in explaining the origin of body scheme: a strict association with other cognitive disorders and impairment of a specific neuronal network responsible for body scheme (Denburg & Tranel 2003, Denes et al. 2000).

The aim of the present study was to answer the following questions:

- 1) Are body scheme disorders present in patients with post-stroke lesions in the PTO region? Three specific disorders were assessed:
  - autotopagnosia (impaired localizing of body parts on the patient's own body, the body of another person, or in a picture);
  - finger agnosia (impaired differentiation, naming and localizing of fingers);
  - right-left disorientation.
- 2) Are there any differences concerning body scheme disorders between patients with lesions of the left and right brain hemisphere?
- 3) Is it possible that body scheme disorders result from impairment of other cognitive functions?

## **MATERIAL AND METHODS**

The study was conducted between April 2004 and June 2005. The experimental group consisted of 16 patients with vascular lesions in the left or right parieto-occipital or temporo-parieto-occipital regions, confirmed by CT or MRI. Of these, 15 patients had ischemic brain lesions, while one person's stroke was hemorrhagic. The control group consisted of 11 persons with no brain lesions.

The following exclusion factors were applied:

- other brain lesions in the CT or MRI;
- low level of consciousness (patient not alert);

- dementia or psychiatric diseases;
- other disorders of the central nervous system;
- somatic disorders that could impair functions of the brain as a whole.

The demographic characteristics in both groups were similar. The average age was  $63.3 \pm 11$  years in the experimental group and  $64.1 \pm 8.5$  years in the control group; males constituted 56.3% of the experimental group and 54.5% of the control group; and the average length of education in the experimental group was  $12 \pm 3$  years, as compared to  $13.7 \pm 2.9$  years in the control group.

To compare these variables, Student's t test was applied for age and education, and the chi-square test for sex. All examined persons were right-handed.

The persons in both groups were informed of the study's purpose and methods; consent to participate was received from all subjects.

### ***Clinical examination***

The entire examination of each patient in the experimental group lasted 60 - 90 minutes, compared to about 30-45 minutes in the control group. In the experimental group the examination was divided into two sessions: neuropsychological and neurological. Because of the lack of psychometrically validated body scheme examination methods in Poland, experimental clinical methods were mainly used. The nature of the specific tasks and the interpretation of their results were adapted by the author. All patients underwent a routine neurological examination during hospitalization in the 2nd Department of Neurology at the Institute of Psychiatry and Neurology in Warsaw. Hemiparesis was present in 9 patients, lateral hemianopsia in 6, and hemianesthesia in 2 patients.

#### ***1. Assessment of cognitive functions***

Clinical tests were used to detect visual agnosia, hemi-inattention syndrome, apraxia, visuospatial disorders, aphasia, attention and memory disorders. Three aspects of body scheme disturbances were then examined: localizing body parts, finger gnosis, and right-left orientation.

Visual gnosis was assessed by measuring recognition of overlapping or crossed-out objects in a picture (Łucki 1995). The results were assessed on a three-point scale: 2 points were granted if all objects were recognized, 1 point if some objects were recognized incorrectly or omitted, or 0 points if most elements were not recognized or incorrectly recognized. The other methods used included the recognition of crossed-out words (Lezak 1995) and three tasks from the Visual Form Discrimination Test (Benton 1968), a multiple choice version, modified by the author, with the model figure visible to the patient at all times. The global score for visual gnosis was obtained by summarizing the results of these tests.

To assess spatial attention, the Test of Visual Neglect was used (Albert 1973), scoring 1 point for normal performance, and Simultaneous Bilateral Stimulation from the Halstead-Reitan battery (Kądziaława 1990) with two trials in visual and two in tactile modality, for a maximum of 4 points.

Ideomotor praxia was examined by imitating hand positions and gestures performed with the nonparetic limb (Łucki 1995, Heilman & Gonzalez 2003); the maximum score for these task was 2 points. The spatial aspects of praxia were examined by imitating two presented spatial configurations of the upper limbs (Łucki 1995, Heilman & Gonzalez 2003) and the Head test (Lezak 1995), for a maximum of 3 points. A "mirror" performance was considered a mistake.

Simple clinical tests (Lezak 1995) were used to assess constructional praxia; the subject was asked to copy and draw figures (cross, cube, house, flower). 2 points were granted for correct drawings, 1 point for maintaining the general shape with some errors (omissions or distortions); 0 points for incorrect performance.

The global scores were counted separately for ideomotor and constructional praxia.

The Clock Drawing Test (Shulman et al. 1986), in a version modified by the author, was used to assess visuospatial functions. The first task was to put the digits in a circle to create a clock face, while the second was to set the hands of the clock to indicate the particular time. For correct performance of each task 3 points were granted, for some visuospatial errors 2 points, for numerous mistakes 1 point and 0 points for completely incorrect performance. In addition, the spatial relations of two-dimensional figures were assessed (0 or 1 point).

Language functions were examined using subtests from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan 1972, Ulatowska et al. 2004). Subtests for language comprehension, naming, and repeating were chosen, as these functions could be particularly important in body scheme orientation. Performance of oral instructions, finding objects in a picture belonging to various categories and complex texts were used to assess comprehension. The oral instructions were derived from another source (Łucki 1995); for each properly understood instruction 1 or 2 points were given, dependent on their difficulty. Other methods were evaluated according to the BDAE manual. The global outcome of language functions was achieved by summarizing the results of these subtests.

Digit Span Forward and Backward, subtests from the Wechsler Adult Intelligence Scale (Brzeziński et al. 2004), were used to assess attention, as well as naming months backward. Visual memory was assessed using three tests from the Visual Form Discrimination Test (Benton 1968), where the time of figure presentation was 10 seconds; for each task 0 - 3 points were granted. Verbal memory was tested by remembering words in one task from the Auditory Verbal Learning Test (Choynowski & Kostro 1980).

## *2. Localizing of body parts*

This aspect of body scheme was examined using the following clinical tests:

- localizing body parts by the patient on his own body and in a picture presenting a human figure;

- recognizing body parts in the same picture;
- naming body parts.

These methods were derived from the Semenza and Goodglass test battery (Semenza 2001). The verbal tasks included:

- pointing to body parts in pictures presenting a human face and a human figure (front and back views): 5 elements appearing in pairs (elbow, arm, hand, calf, foot) seen from the back, and 10 paired elements on the face and whole human figure from the front (knee, thigh, arm, forearm, hand, foot, ear, eyebrow, cheek), always identifying their right or left side;
- pointing to 5 paired body parts on the patient's own body with eyes opened and closed.

Nonverbal tasks were:

- localizing one's own body parts according to elements pointed out in a picture (5 paired elements seen from the back and 5 seen from the front);
- pointing to body parts in a picture presenting a human figure (5 paired elements seen from the back and 5 seen from the front) according to elements touched on the patient's body.

To sum up, a maximum of 40 points could be earned for the verbal and nonverbal tasks. Also, naming of body parts in the picture was assessed (10 elements, max. 10 points), but this score did not contribute to a diagnosis of autotopagnosia, according to the definition (Semenza 2001).

The errors were classified as:

- contiguous, e.g. "arm - forearm";
- conceptual, e.g. "elbow - knee";
- random.

All of these were taken as indicators of autotopagnosia.

### *3. Finger gnosis*

For assessment of this function, a battery of clinical trials was created, using methods derived from the literature (Sauguet et al. 1971, Kądziaława 1990, Walsh 2000). Finger naming, comprehension of their names, and finger localizing were tested with following tasks:

- assessing how many fingers are present between two of the subjects' fingers touched simultaneously, without visual control (5 trials);
- imitation of presented spatial configurations of fingers (4 trials);
- pointing at fingers in a picture presenting a hand with fingers oriented away from the subject (5 trials);
- pointing at fingers on both hands of a person sitting opposite (10 trials);
- finger naming in a picture (5 trials);
- a nonverbal task, indicating on a picture of the right or left hand which finger had been touched on the subject's hand hidden from view; two trials were conducted; 2 points were granted for correct recognition of fingers II, III and IV, 1 point for fingers I and V.

The total score from these tests was 16 points. The subjects were free to indicate fingers using their anatomical numbers or by pointing to them in a picture, if they were not familiar with their names. The upper limb with preserved superficial sensation was used in all trials.

#### *4. Right – left orientation*

This function could be assessed by examining the results of some of the tests mentioned above, particularly the tasks engaging the process of "mental rotation":

- pointing to body parts in a picture presenting a human face or figure seen from the front;
- nonverbal trials concerning localizing body parts and pointing at the fingers of a person sitting opposite.

The disorder was diagnosed if two or more errors were made in these tasks.

#### *5. Arranging two-dimensional models of the human body from elements*

Arranging of two-dimensional models of the human figure, face and hand from elements, a subtest from the Wechsler Adult Intelligence Scale (Brzeziński et al. 2004), was used as a supplementary method. The result of each task is the number of correct connections between elements. Each task had its time limit, and additional points were granted according to the test manual. Observations were made as to whether performing of the task was based on the early recognition of the object as a whole, or on perceived spatial relations between particular elements.

### **Statistical methods**

The results from the body scheme examination were compared between the experimental and control groups, as well as between two subgroups of patients with left or right brain hemisphere lesions. Student's t test was conducted for localizing body parts and finger gnosis, and the chi-square test for right-left orientation. The t statistic was also used to compare the level of other cognitive functions between both groups and subgroups.

Linear correlation was performed to analyse relations between the results of the body scheme examination and other cognitive functions in the experimental group.

SPSS 12.0 PL for Windows software was used for statistical analysis.

## **RESULTS**

Upon analysis of the results from body scheme examination in the experimental and control group, statistically significant differences were found for two variables: finger gnosis and arranging of two-dimensional models of the human body, in favor of the control group (Table 1). The difference observed

for finger gnosis was associated particularly with two tasks: pointing at fingers on picture of the hand -  $t(15) = 2.334$ ,  $p < 0.05$  - and pointing at fingers on both hands of a person sitting opposite:  $t(17, 15) = 2.439$ ,  $p < 0.05$ . No differences were found for localizing body parts (Table 1) and right-left orientation: chi-square (1) = 0.759,  $p > 0.05$ .

No statistically significant results were obtained for any analysed variable when comparing the subgroup with left hemisphere lesions and the control group; this could be partially due to the small sample size. On the other side, comparison between the subgroup with right side lesions and the control group revealed significant differences for finger gnosis and arranging of two-dimensional models of the human body, in favor of the control group (Table 2).

The results from the comparison of the other cognitive functions between the two groups are presented in Table 1. Statistically significant differences were found for visual gnosis, constructional praxia and spatial attention; dis-

Table 1. Comparison of the experimental and control groups in respect to body scheme and other cognitive functions

Table 2. Comparison of subgroups with lesions in the left or right cerebral hemisphere with the control group in respect to cognitive functions

Variable	LEFT HEMISPHERE LESION – CONTROL GROUP		RIGHT HEMISPHERE LESION – CONTROL GROUP	
	statistic t	p value	statistic t	p value
LOCALIZING BODY PARTS	0.988	0.366	1.000	0.341
FINGER GNOSIA	1.752	0.100	2.429	0.025
ARRANGING TWO – DIMENSIONAL MODELS OF THE HUMAN BODY	1.634	0.123	3.755	0.001
VISUAL GNOSIA	2.636	0.019	2.359	0.036
SPATIAL ATTENTION	-	-	2.785	0.021
IDEOMOTOR PRAXIA	0.491	0.631	1.337	0.197
CONSTRUCTIONAL PRAXIA	0.877	0.413	3.776	0.001
VISUOSPATIAL ABILITIES	0.326	0.749	3.162	0.005
LANGUAGE FUNCTIONS	1.575	0.176	1.639	0.133
ATTENTION	2.054	0.058	1.444	0.165
MEMORY	1.008	0.329	0.506	0.618

orders of these functions were present in the experimental group. In the case of visual gnosis the difference was determined by the results of two tasks: recognizing overlapping or crossed-out objects in a picture –  $t(24.56) = 2.207$ ,  $p < 0.05$  - and recognizing crossed-out words:  $t(15) = 2.236$ ,  $p < 0.05$ . In the case of hemi-inattention syndrome, the differences were established by Simultaneous Bilateral Stimulation:  $t(15) = 3.230$ ,  $p < 0.01$ . In the case of



Table 3. Correlations between two aspects of body scheme and other cognitive functions in the experimental group

Variable	LOCALIZING BODY PARTS	FINGER GNOSIA
VISUAL GNOSIA	0.213*	0.011*
IDEOMOTOR PRAXIA	0.031*	0.028*
CONSTRUCTIONAL PRAXIA	- 0.147*	0.232*
VISUOSPATIAL ABILITIES	- 0.218*	0.154*
LANGUAGE FUNCTIONS	0.429**	0.563**
ATTENTION	0.191*	0.496*
MEMORY	0.228*	0.630***

\*  $p > 0.05$

\*\*  $p < 0.05$

\*\*\*  $p < 0.01$

visuospatial abilities, there was a statistical tendency to differentiation ( $p=0.057$ ), in favor of the control group. No significant differences were present for ideomotor praxia, language functions, attention level, or memory.

A comparison between the subgroups with LH lesions and the control group revealed a significant difference only for visual gnosis; the disorder was present with LH damage. On the other hand, significant differences were seen between the subgroup with RH lesions and the control group in the areas of visual gnosis, constructional praxia, visuospatial abilities, and spatial attention (Table 2). The differences were determined by the results of the modified Clock Drawing Test for visuospatial abilities -  $t(19) = 2.982, p < 0.01$  - and Simultaneous Bilateral Stimulation for hemi-inattention syndrome:  $t(9) = 4.146, p < 0.01$ .

Table 3 presents the correlations between particular cognitive functions in the experimental group, in the form of Pearson ratios.

Statistically significant positive correlations were found between localizing body parts and language functions, as well as between finger gnosis, language functions, and memory.

## DISCUSSION

The present study was conducted in two groups: patients with a post-stroke lesion in a particular brain area and healthy persons; both groups were similar in sex distribution, mean age and level of education. Because informal clinical tasks were mainly used in the study, the results in the experimental group were compared to the control group. If a statistically significant difference between groups was present, a disorder of a particular cognitive function in the experimental group was diagnosed.

The following conclusions were reached:

- In the group of patients with PTO lesions (regardless of cerebral hemisphere) disorders of finger gnosis were present.
- In this same group there were problems with arranging two-dimensional models of the human body;
- No significant differences between groups were found in respect to localizing body parts and right-left orientation.

Body scheme disorders were present in the experimental group, but they were limited to finger agnosia. Healthy persons from the control group also had some problems with tasks concerning this function. These findings are consistent with a view that among body scheme disorders finger agnosia occurs most often, while autotopagnosia is observed rather sporadically (Frederiks 1985).

The present study supports the supposition that right-left disorientation occurs not only after brain damage, but also in some healthy individuals; it was noticeable particularly in tasks engaging the process of mental rotation. The coexistence of finger agnosia and right-left disorientation was observed in this population, a fact which indicates that similar brain structures may be responsible for both disorders.

In patients with RH lesions, finger agnosia and problems with arranging two-dimensional body models occurred more frequently than in the subgroup with LH lesions. For other body scheme disorders no marked lateralization of brain lesion was observed.

According to the majority of researchers, body scheme disorders result from damage to the brain hemisphere responsible for language functions, mainly the left hemisphere (Denes 1989, Denburg & Tranel 2003). However, the association between finger agnosia and damage to the right hemisphere, as observed in the present study, supports the hypothesis of Kinsbourne and Warrington (Denburg & Tranel 2003). According to this hypothesis, finger agnosia results from a visuospatial disorder, so it could occur when the lesion is located in the right hemisphere, particularly the right parietal lobe. Other studies confirming this hypothesis have been conducted:

- in the 1970s, in which right-handed persons with RH and LH brain lesions were compared (Benton 1985)
- in 2005, when functional neuroimaging was used to suggest a precise location in the right parietal lobe for the brain structures responsible for finger gnosis (Chaminade et al. 2005).

Comparison of the other cognitive functions in the experimental and control groups revealed visual agnosia, hemi-inattention syndrome, constructional apraxia and visuospatial disorders in the former group. These disorders were more frequent in individuals with RH lesions. Comparison between the subgroups with RH and LH side lesions showed that visuospatial disorders, constructional apraxia and hemi-inattention syndrome are associated with RH damage (Table 2).

Body scheme disorders in this population seem to be independent from other cognitive dysfunctions. Although constructional apraxia, visuospatial disorders and hemi-inattention syndrome were observed in patients with parieto-occipital lesions, they did not influence the results of the body scheme examination (localizing body parts and finger gnosis), which was revealed by linear correlations (Table 3). Autotopagnosia and finger agnosia seem to be associated only with language and memory disorders (Table 3). It is difficult, however, to discuss these relations, particularly the role of aphasia, on the basis of the data presented here; the problem is rather complex and was not the purpose of the present study.

The results of the present study support the hypothesis that there exists a specific neuronal system or central representation of the body as a three-dimensional object (Denes et al. 2000). Data concerning the lateralization of the brain lesions responsible for body scheme disorders is not convincing, however, because of its limitation to finger agnosia and the small size of the study groups.

Lesions in the right parietal lobe can lead to numerous disorders of body consciousness and scheme, such as anosognosia or hemiasomatognosia (Frederiks 1985). Hypothetically, they could also cause other disorders, e.g. finger agnosia. It is possible that specific neuronal networks, located in the associative cortex of the right parietal lobe, are responsible for sensory and spatial perception of fingers. On the other side, when we think of finger gnosis in terms of naming and understanding instructions or concepts, these functions are probably regulated by the left hemisphere. We should not forget about the integration processes between two hemispheres, which enable the processing of many cognitive functions (Walsh 2000). Because of this fact, the idea of a specific functional system responsible for body scheme should be understood rather as a cooperation of various brain structures and a particular hemispheric domination.

The results of this study, which should be treated as a pilot study, do not allow for the formulation of clear conclusions; however, they may encourage further investigation. Methods of functional brain imaging should be used in research directed towards the origin and location of central body representation, as well as body scheme disorders.

The pathomechanisms of numerous phenomena, defined as body scheme disorders, remain uncertain and even somewhat mysterious. Their detection would be important for the better understanding of these disorders and the proper rehabilitation of stroke patients.

## **CONCLUSIONS**

Body scheme disorders in individuals after stroke with PTO lesions can be detected with the use of appropriate diagnostic methods. One of the most frequent disorders seems to be finger agnosia. This phenomenon was observed

in the current population mainly after RH damage, which suggests that finger agnosia may be the result of a specific spatial disorder. Moreover, the examined aspects of body scheme (localizing body parts, finger gnosia) seem to be independent of other cognitive functions, which can be viewed as an argument for a distinct brain representation of body scheme.

## REFERENCES

- Albert, M. (1973). A simple test of visual neglect. *Neurology*, 23, 658-664.
- Benton, A. (1968). *Der Benton - Test*. Bern: Hans Huber Verlag
- Benton, A. (1985). Body scheme disturbances: finger agnosia and right - left disorientation. In: K. M. Heilman, E. Valenstein (eds.), *Clinical neuropsychology* (pp. 115- 129). New York: Oxford University Press.
- Brzeziński, J., Gaul, M., Hornowska, E. et al. (2004). *Skala Inteligencji D. Wechslera dla Dorosłych, Wersja Zrewidowana - Renormalizacja WAIS-R (PL)*. Warsaw: Pracownia Testów Psychologicznych PTP.
- Chaminade, T., Meltzoff, A., Decety, J. (2005). An fMRI study of imitation: action representation and body scheme. *Neuropsychologia*, 43, 115-127.
- Choynowski, M., Kostro, B. (1980). *Podręcznik do "Testu Piętnastu Słów" A. Reya*. In: M. Choynowski (ed.), *Testy psychologiczne w poradnictwie wychowawczo-zawodowym* (pp. 101-146). Warsaw: PWN.
- Denburg, N.L., Tranel D. (2003). Acalculia and disturbances of the body scheme. In: K. M. Heilman, E. Valenstein (eds.), *Clinical Neuropsychology* (pp. 161-184). New York: Oxford University Press.
- Denes, G. (1989). Disorders of body awareness and body knowledge. In: F. Boller, J. Grafman, (eds.), *Handbook of neuropsychology*, Vol. 2 (pp. 207-225). Amsterdam: Elsevier Science Publishers.
- Denes, G., Cappelletti, J. Y., Zilli, F. D. et al. (2000). A category-specific deficit of spatial representation: the case of autotopagnosia. *Neuropsychologia*, 38, 345- 350.
- Frederiks, J. A. M. (1985). Disorders of the body scheme. In: P. J. Vinken, J. A. M. Frederiks, *Handbook of clinical neurology* (pp. 207-235). Amsterdam: Elsevier Science Publishers.
- Goodglass, H., Kaplan, E. (1972). *The assessment of aphasia and related disorders*. Philadelphia: Lea & Febiger.
- Haggard, P., Wolpert, D. M. (2005). Disorders of body scheme. In: H.-J. Freund, M. Jeannerod, M. Hallett, R. Leiguarda (eds.), *Higher-order motor disorders*. Oxford: Oxford University Press, [www.hera.ucl.ac.uk/sml/publications/papers/HagWol04.pdf](http://www.hera.ucl.ac.uk/sml/publications/papers/HagWol04.pdf)
- Heilman, K.M., Gonzalez Rothi, L.J. (2003). Apraxia. In: K. M. Heilman, E. Valenstein (eds.), *Clinical neuropsychology* (pp. 215-235). New York: Oxford University Press.
- Kądziaława, D. (1990). *Podręcznik do baterii testów neuropsychologicznych Halsteada - Reitana*. Warsaw: Laboratorium Technik Diagnostycznych, Wydział Psychologii UW.
- Lezak, M.D. (1995). *Neuropsychological assessment*, 3rd ed. New York & Oxford: Oxford University Press.
- Łucki, W. (1995). *Zestaw prób do badania procesów poznawczych u pacjentów z uszkodzeniami mózgu*. Warsaw: Pracownia Testów Psychologicznych PTP.
- Sauguet, J., Benton, A. L., Hécaen, H. (1971). Disturbances of the body scheme in relation to language impairment and hemispheric locus of lesion. *Journal of Neurology, Neurosurgery and Psychiatry*, 34, 496-501.
- Semenza, C. (2001). Disorders of body representation. In: R. S. Berndt (ed.), *Handbook of neuropsychology*, 2nd ed., vol. 3 (pp. 285-303). Amsterdam: Elsevier.
- Shulman, K.I., Shedletsky, R., Silver, I.L. (1986). The challenge of time: clock drawing and cognitive function in the elderly. *International Journal of Geriatric Psychiatry*, 1, 135-140.

Ulatowska, H. K., Sadowska, M., Kądziaława, D. (2004). Bostoński Test do Diagnozy Afazji. Adaptacja polska. Wersja eksperymentalna (distributed by the Institute of Psychiatry and Neurology).

Walsh, K. (2000). Neuropsychologia kliniczna. Warsaw: PWN.

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